SPACE ORDNANCE SYSTEMS

Test Report 8745

CONTRACT NAS 9-16169

FINAL REPORT

SLIDE RELEASE DEVICE

Prepared for

NASA

Lyndon B. Johnson Space Center

Houston, Texas 77058

by

SPACE ORDNANCE SYSTEMS

Canyon Country, Calif.

Ref: 3F-1024-10-10

SOS

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APPENDICES

I. INTRODUCTION

The Space Shuttle Orbiter vehicle is attached to the External Tank at three (3) points: one (1) forward and two (2) aft. The current baseline is a separation bolt at the forward attach point and frangible nuts at the aft.

Space Ordnance Systems conceived a new mechanism for the forward attach point which offers the following advantages over the existing separation bolt.

- o Reduced weight
- o Reduced shock
- o Re-useable components
- o Reduced cost

The concept utilizes a slider release mechanism and shank follower. In order to demonstrate the feasibility of this device, an unsolicited proposal was submitted to NASA which resulted in Contract NAS 9-16169, "Prototype Demonstration of a Slide Release Device for Orbiter/External Tank Forward Attachment".

The design, test results and recommendations of the program are contained in this report. The prototype test

article exhibited no significant damage during testing and remains available for subsequent demonstrations or tests.

II. SUMMARY

The goals of the program as defined in the Statement of Work are summarized as follows.

- o Design a mechanism within envelope and functional loads of existing separation device.
- o Fabricate prototype device capable of 10 refurbishments.
- o Conduct ten (10) functional tests.
- o Demonstrate ultimate load capability.

All of the above goals were accomplished. Some difficulty was encountered in the application of the side load. This problem was associated with the functional test fixture.

The tests results indicated a pressure actuated shank follower would be desirable in the next generation design. Additionally, the functional test fixtures should simulate the actual side load conditions experienced in vehicle structure.

III. DESIGN DESCRIPTION

A. Requirements.

The requirements as stated in the original Statement of Work was to develop a preliminary design which was in compliance with the requirements of Rockwell Specification MC 325-0014. Additionally, the mechanism must be interchangeable with the existing Spherical Bearing and External Tank Fitting.

Subsequent communication with NASA/JSC revised the working loads to 74,000 lb. tension and 1,380 lb. side load.

The mechanism design was complete based on the original loads, therefore the mechanism is capable of load increases to the original requirement.

The slide release mechanism is shown in Figure III-1. A functional description follows.

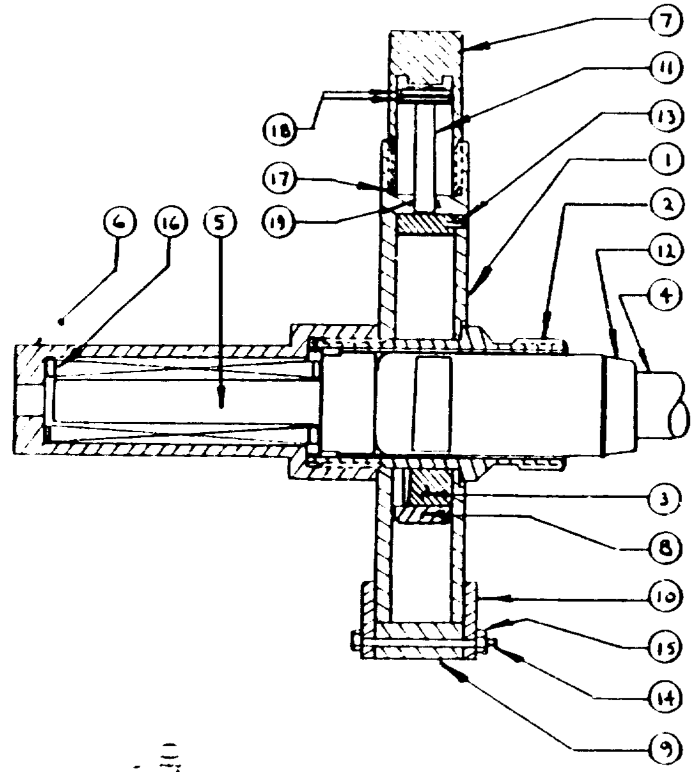

Figure III-1

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						23
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						20
2	1	2-015E515-80	O-RING			19
2	2	2-028E515-80	O-RING			18
2	1	3-924E515-80	O-RING •			17
1	1	2X12XMD	DIE SPRING			16
	1	1/4-28	LOCKNUT		SST	15
	1	1/4-28X3LG	BOLT		SST	14
	1	116649-1	SHEAR PIN			13
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	1	116640-1	MANIFOLD			7
	1	116639-1	COVER			6
	1	116638-1	FOLLOWER			5
	1	116637-1	SHANK			4
	1	116636-1	SLIDER			3
	1	116635-1	SLEEVE			2
	1	116634-1	BODY			1
	REQD	PART NO.	DESCRIPTION	SIZE	SPEC	ITEM NO.

PARTS LIST

2 PARKER SEAL CO., LEXINGTON KY

1 RAYMOND DIE SPRING CO., CORRY PA

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

NEXT ASSY	USED ON
—	P/L 116633-1

APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOL { .XX ± .03; .XXX ± .010; ANGLES ± 0°30'
BREAK SHARP EDGES .005 TO .015
FILLET RADII .010 MAX
SURFACES PER RMS 125
DIMENSIONS APPLY AFTER PLATING
THREADS PER NBS H28

HEAT TREAT

FINISH

DRAWN	BUNKER	3/10/81
CHECK		
QA		
ENGR	Bunker	3/10/81
CH ENGR	E.J. Bailey	3/10/81

SPACE ORDNANCE SYSTEMS
25977 SAND CANYON RD. CANYON COUNTRY, CALIFORNIA 91351

SOS

SLIDE RELEASE
MECHANISM

SIZE	CODE IDENT NO.	DWG NO.
C	19113	116633

SCALE HALF | WEIGHT | SHEET 1 of 1

116633

B. Functional Description - The unit was designed to take maximum advantage of the available shank diameter, as defined by the existing monoball. This point of view provides the maximum load carrying capacity without external change.

The device installs in the monoball just as does the shear bolt, by threading in the completely assembled condition.

Actuation is quite different. Instead of axially breaking the shank by very high pressure (on the order of 60,000 psi) using a very large force (over 235,000 pounds) this mechanism releases the shank by cross-axis movement against a lubricated surface. The unit will probably never see more than 12,000 psi during an overload firing and requires only about 7,100 pounds to release an 80,000 pound load.

Once free, the shank is driven out of the monoball by an axially pre-compressed spring.

Advantages from this device relative to its predecessors are considerable. Its final weight can be as low as thirty pounds versus over sixty for the shear bolt. Its cartridge will contain less than one gram of powder versus 12 and 13.2 for the separation and shear bolts. Finally, it is re-useable and the others are not. The expensive components show no significant wear after eleven actuations under load.

C. Component Description - The following describes the components while assembling the unit. The detail components are included at the end of this section.

An aluminum attenuator slips loosely over the end of the slider. The slider is then slipped loosely into the body, far enough to capture the attenuator.

The main bores through the slider and body are then exactly aligned and the sleeve is loosely slipped through both of them till it bottoms against the body. By rotating the sleeve till it's webs line up with the slider, the slider can then be moved farther into the body, capturing the sleeve.

The shank can then be slipped loosely through the sleeve if the slider is properly positioned. (In the unit tested, it was possible to install the shank incorrectly. This will be eliminated.) When aligned properly, the slider can be driven home, bottomed in the body capturing the shank.

The slider is then pinned in position, forming the basic load carrying and load releasing portion of the device.

The entire shank is highly stressed, but only a pair of flats on the slider, one face of the body and a small section of the sleeve are highly stressed. Thus, the majority of the body can be aluminum with savings in cost as well as weight, but unfortunately, the sleeve and slider do not appear to permit such savings; it is recommended that the shank, sleeve, slider and one face of the body remain inconel.

The attenuator end of the body is closed by slipping an end plate over the body and an end cover over both the end plate and the body. These may then be pinned, bolted or lockwired together. This particular configuration was selected for ease of disassembly after deforming of the attenuator between the end cap and body.

A separate power supply portion threads into the body at the opposite end from the attenuator. It is comprised of a dual sealed piston in a manifold. It contains two cartridge ports for redundant operation. The piston shank in entering the body, passes through an environmental seal.

Firing either cartridge drives the piston against the slider, shearing the aluminum shear pin and driving the slider into impacting its attenuator against the end cap, thus releasing the shank but not th sleeve. The piston and manifold can be made of aluminum.

Once released, the shank is driven out of the unit and monoball by a pre-compressed die spring. ..e die spring is compressed between a cover and a follower. The cover threads onto the sleeve and bottoms on the body. It may be lockwired in place, but due to the forces involved, it is unlikely it can inadvertently unscrew. Having driven the shank from the monoball, the follower closes the hole precisely. It is keyed into the sleeve. The cover and follower may be aluminum. The cover tested was aluminum but the follower was inconel.

REVISIONS			
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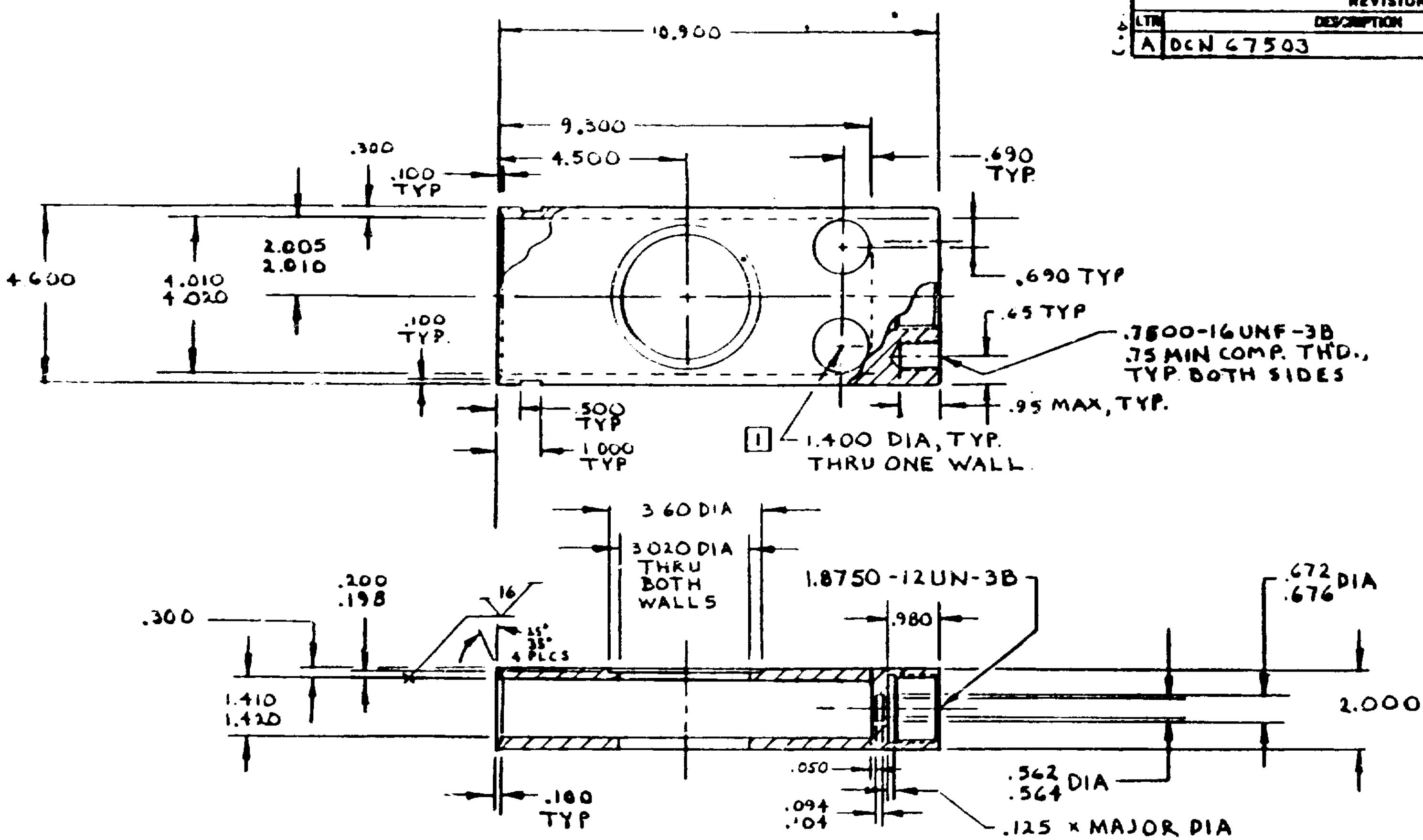

[1] THESE HOLES INCLUDED ONLY TO FACILITATE MANUFACTURE: TO PERMIT BROACHING OF INTERIOR.

REQD	PART NO.	DESCRIPTION	SIZE	SPEC	ITEM NO.
	-1	17-4PH CRES		AMS 5643	1

PARTS LIST

NEXT ASSY	USED ON
116633-1	116633-1

APPLICATION

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOL .XX ± .03, .XXX ± .010, ANGLES ± 0°30'
BREAK SHARP EDGES .005 TO .015
FILLET RADII .010 MAX
SURFACES PER RMS 125
DIMENSIONS APPLY AFTER PLATING
THREADS PER NBS H28
HEAT TREAT H1025 PER MIL-H-6875
FINISH ELECTROPOLISH, .0005 MAX. MAT'L. REMOVAL

DRAWN	BUNKER	10/13/80
CHECK		
QA	C. [illegible]	10-16-80
ENGR	[illegible]	10/13/80
CH ENGR	[illegible]	10/14/80

SPACE ORDNANCE SYSTEMS
25977 SAND CANYON RD. CANYON COUNTRY, CALIFORNIA 91351

BODY

SIZE	CODE IDENT NO.	DWG NO.
C	19113	116634

SCALE HALF | WEIGHT | SHEET 1 of 1

A 116634

LTR	DESCRIPTION	DATE	APPROVED
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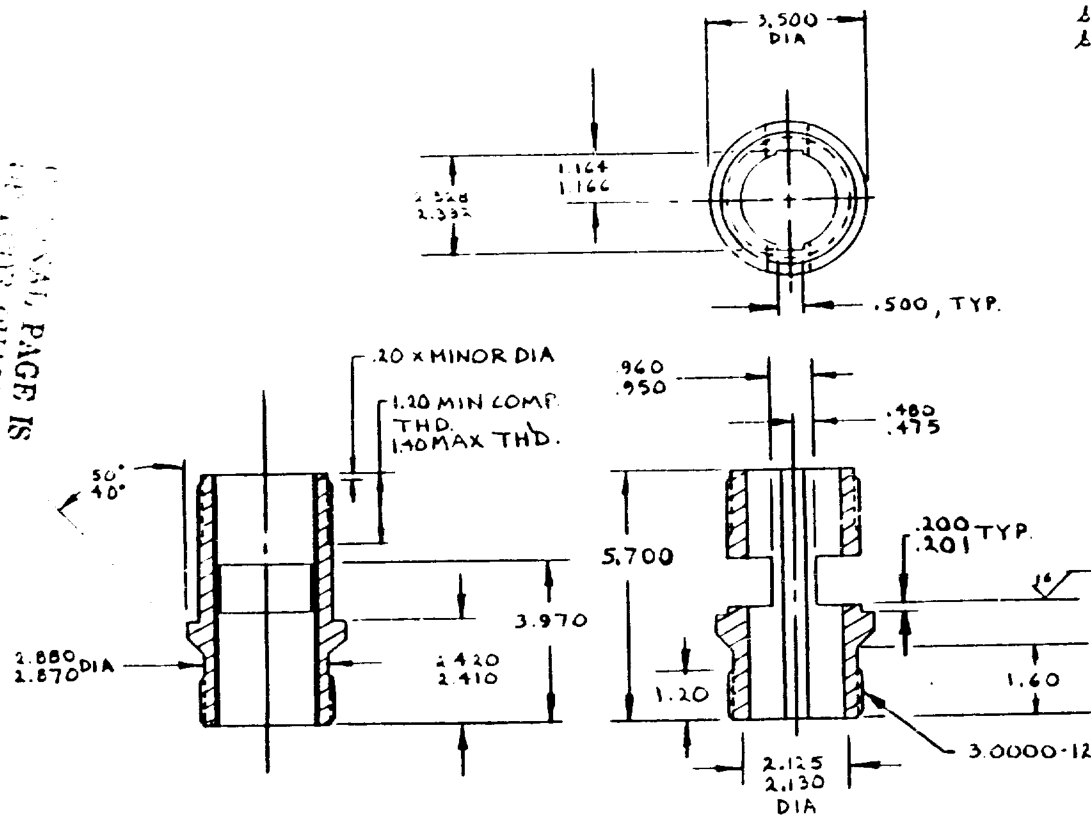

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3. FLUORESCENT PENETRANT INSPECT PER MIL-I-6866, TYPE I, METHOD B

2 HEAT TREAT TO 180K PSI MIN UTS PER PARA 3.4.1.2 OF AMS 5662.

1 THDS. PER MIL-S-8879.

REQD	PART NO.	DESCRIPTION	SIZE	SPEC	ITEM NO.
	-1	INCONEL 718		AMS 5662	1

PARTS LIST

	NEXT ASSY	USED ON
-1	116633-1	P/L 116633-1

APPLICATION

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
TOL { .XX ± .03; .XXX ± .010; ANGLES ± 0°30'
BREAK SHARP EDGES .005 TO .015
FILLET RADII .010 MAX
SURFACES PER AMS 125
DIMENSIONS APPLY AFTER PLATING

HEAT TREAT 2

FINISH

DRAWN	BUNKER	10/9/80
CHECK		
QA	Clifford Reed	10/15/80
ENGR	Bunker	11/11/80
CH ENGR	[signature]	11/11/80

SPACE ORDNANCE SYSTEMS
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SLEEVE

SIZE C | CODE IDENT NO 19113 | DWG NO. 116635

SCALE HALF | WEIGHT | SHEET 1 of 1

B 116635

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
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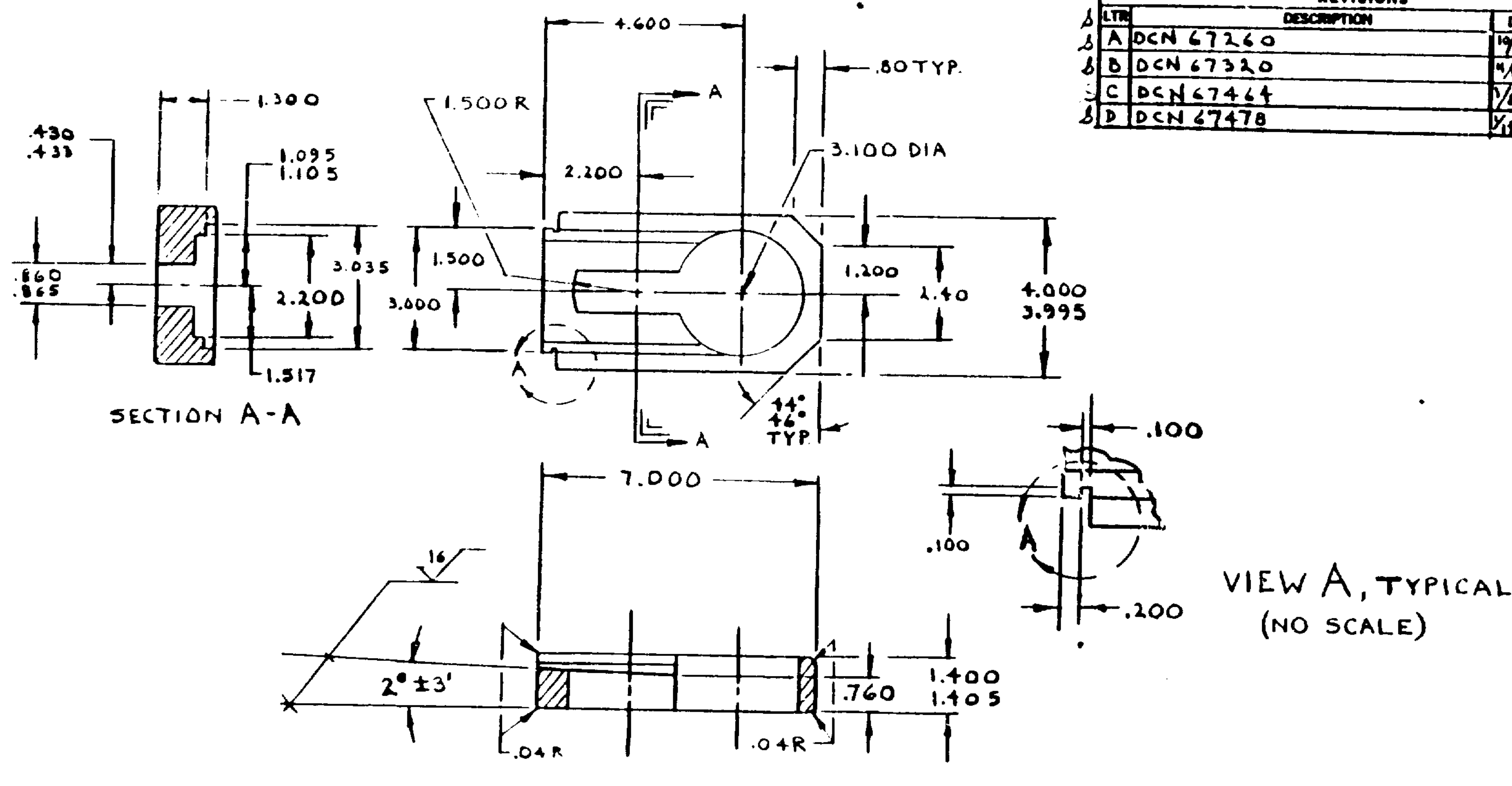

3. DRY FILM LUBRICATE PER MIL-L-8937. LUBRICANT SHALL BE ELECTROFILM CORP. 5306 L. DIMENSIONS APPLY BEFORE DRY FILM LUBRICATION.

2. FLUORESCENT PENETRANT INSPECT PER MIL-I-6866, TYPE I, METHOD B.

[1] HEAT TREAT TO 180K PSI MIN UTS PER PARA. 3.4.1.2 OF AMS 5662.

REQD	PART NO.	DESCRIPTION	SIZE	SPEC	ITEM NO.
	-1	INCONEL 718		AMS 5662	1

PARTS LIST

NEXT ASSY	USED ON
116633-1	P/L 116633

-1

APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOL { .XX ± .03; .XXX ± .010; ANGLES ± 0°30'
BREAK SHARP EDGES .005 TO .015
FILLET RADII .010 MAX
SURFACES PER RMS 125
DIMENSIONS APPLY AFTER PLATING
THREADS PER NBS H28

HEAT TREAT [1]

FINISH

DRAWN	BUNKER	10/13/80
CHECK		
QA	Clifford Reed	
ENGR	Bunker	10/13/80
CH ENGR		10/16/80

SPACE ORDNANCE SYSTEMS
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SOS

SLIDER

SIZE	CODE IDENT NO.	DWG NO.
C	19113	116636

SCALE HALF | WEIGHT | SHEET 1 of 1

D 116636

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
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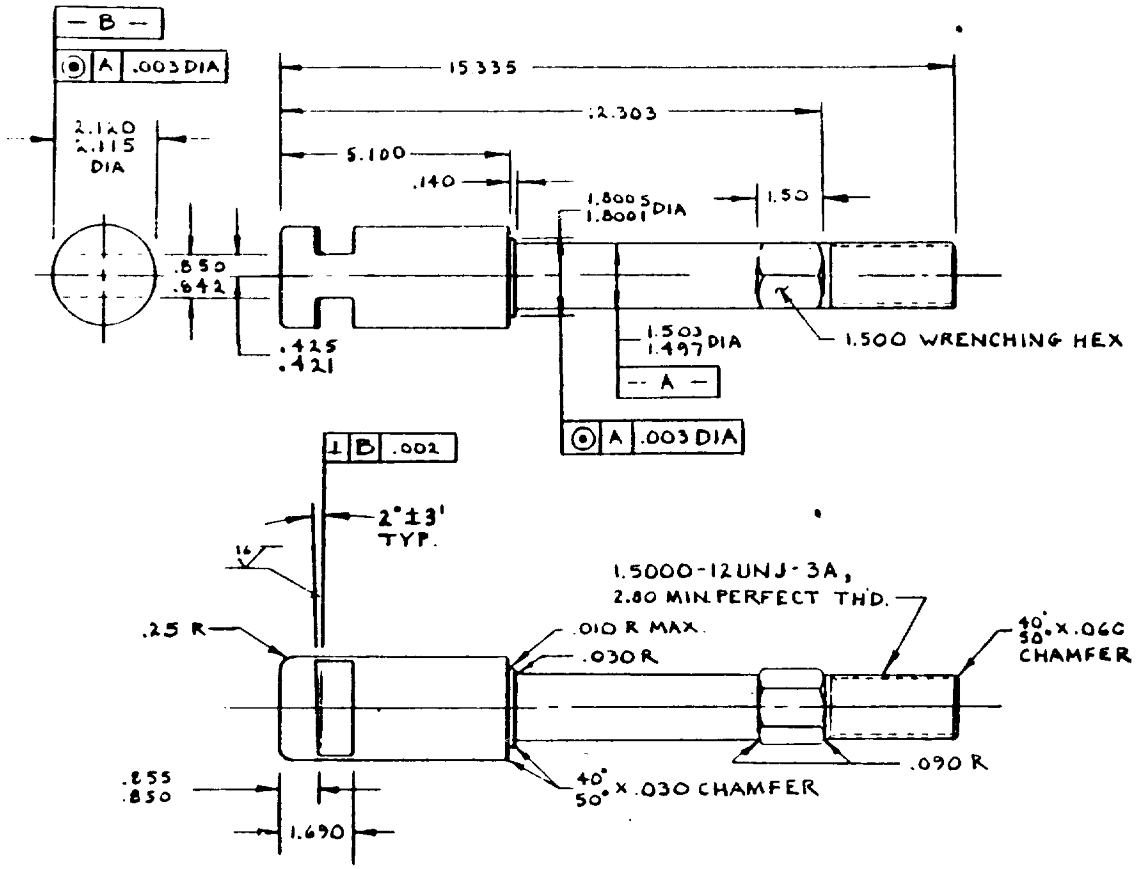

3. FLUORESCENT PENETRANT INSPECT PER MIL-I-6866, TYPE I, METHOD B

$\boxed{2}$ HEAT TREAT TO 180KPSI MIN UTS. PER PARA 3.4.1.2 OF AMS 5662.

1. THDS. PER MIL-S-8879.

REQD	PART NO.	DESCRIPTION	SIZE	SPEC	ITEM NO
	-1	INCONEL 718		AMS 5662	1

PARTS LIST

	NEXT ASSY	USED ON
-1	116633-1	F/L 116633-1

APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOL { .XX ± .03; .XXX ± .010; ANGLES ± 0°30'
BREAK SHARP EDGES .005 TO .015
FILLET RADII .010 MAX
SURFACES PER RMS 125
DIMENSIONS APPLY AFTER PLATING

HEAT TREAT $\boxed{2}$

FINISH

DRAWN	BUNKER	
CHECK		
QA	Clifford Reed	10-16-80
ENGR	Bunker	
CH ENGR		

SPACE ORDNANCE SYSTEMS
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SHANK

SIZE	CODE IDENT NO.	DWG NO.
C	19113	116637

SCALE HALF WEIGHT SHEET 1 of 1

A 116637

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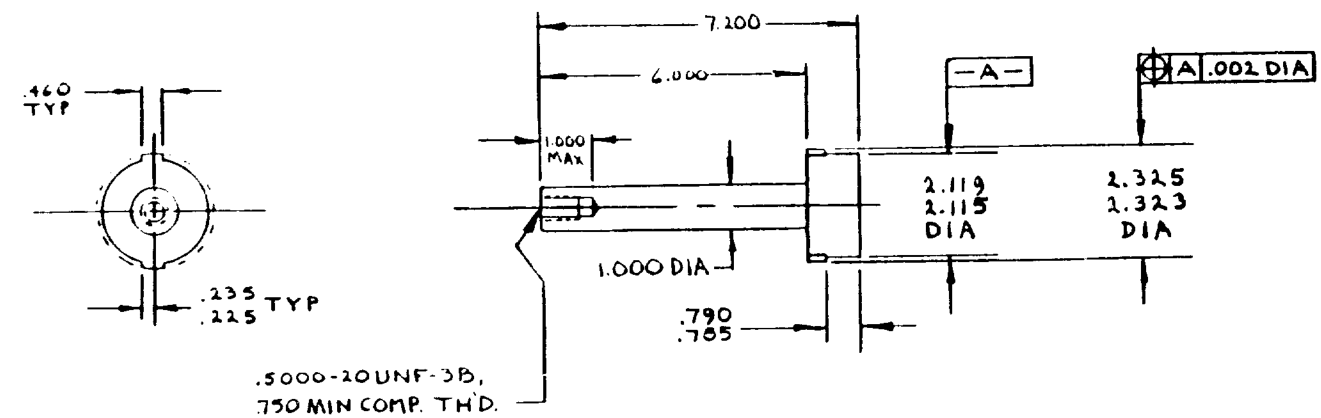

2. FLUORESCENT PENETRANT INSPECT PER MIL-I-6866, TYPE I, METHOD B

[1] HEAT TREAT TO 180KPSI MIN UTS PER PARA. 3.4.1.2 OF AMS 5662.

REQD	PART NO.	DESCRIPTION	SIZE	SPEC	ITEM NO.
	-1	INCONEL 718		AMS 5662	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOL { .XX ± .03; .XXX ± .010; ANGLES ± 0°30'
BREAK SHARP EDGES .005 TO .015
FILLET RADII .010 MAX
SURFACES PER AMS 125
DIMENSIONS APPLY AFTER PLATING
THREADS PER NBS H28

DRAWN	BUNKER	10/1/80
CHECK		
QA	Clifford Reed	10-6-80
ENGR		10/13/80
CH ENGR		10/14/80

HEAT TREAT [1]

FINISH

NEXT ASSY	USED ON
-1 116633-1	116633-1

APPLICATION

SPACE ORDNANCE SYSTEMS
25977 SAND CANYON RD. CANYON COUNTRY, CALIFORNIA 91351

FOLLOWER

SIZE	CODE IDENT NO.	DWG NO.
C	19113	116638

SCALE HALF WEIGHT SHEET 1 of 1

B 116638

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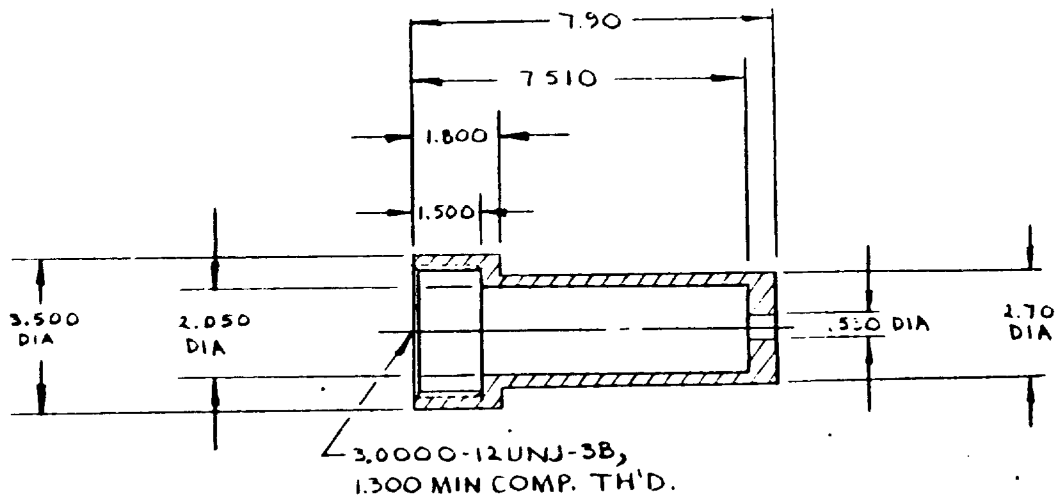

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	-1	6061-T6 AL ALLOY		QQ-A-200/8D	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOL { .XX ± .03, .XXX ± .010, ANGLES ± 0°30'
BREAK SHARP EDGES .005 TO .015
FILLET RADII .010 MAX
SURFACES PER RMS 125
DIMENSIONS APPLY AFTER PLATING
THREADS PER MBS H28

HEAT TREAT

FINISH

DRAWN	BUNKER	
CHECK		
QA		
ENGR		
CH ENGR		

	NEXT ASSY	USED ON
-1	116633-1	P/L 116633-1

APPLICATION

SPACE ORDNANCE SYSTEMS
25977 SAND CANYON RD. CANYON COUNTRY, CALIFORNIA 91351

COVER

SIZE C | CODE IDENT NO. 19113 | DWG NO. 116639

SCALE HALF | WEIGHT | SHEET 1 of 1

A 116639

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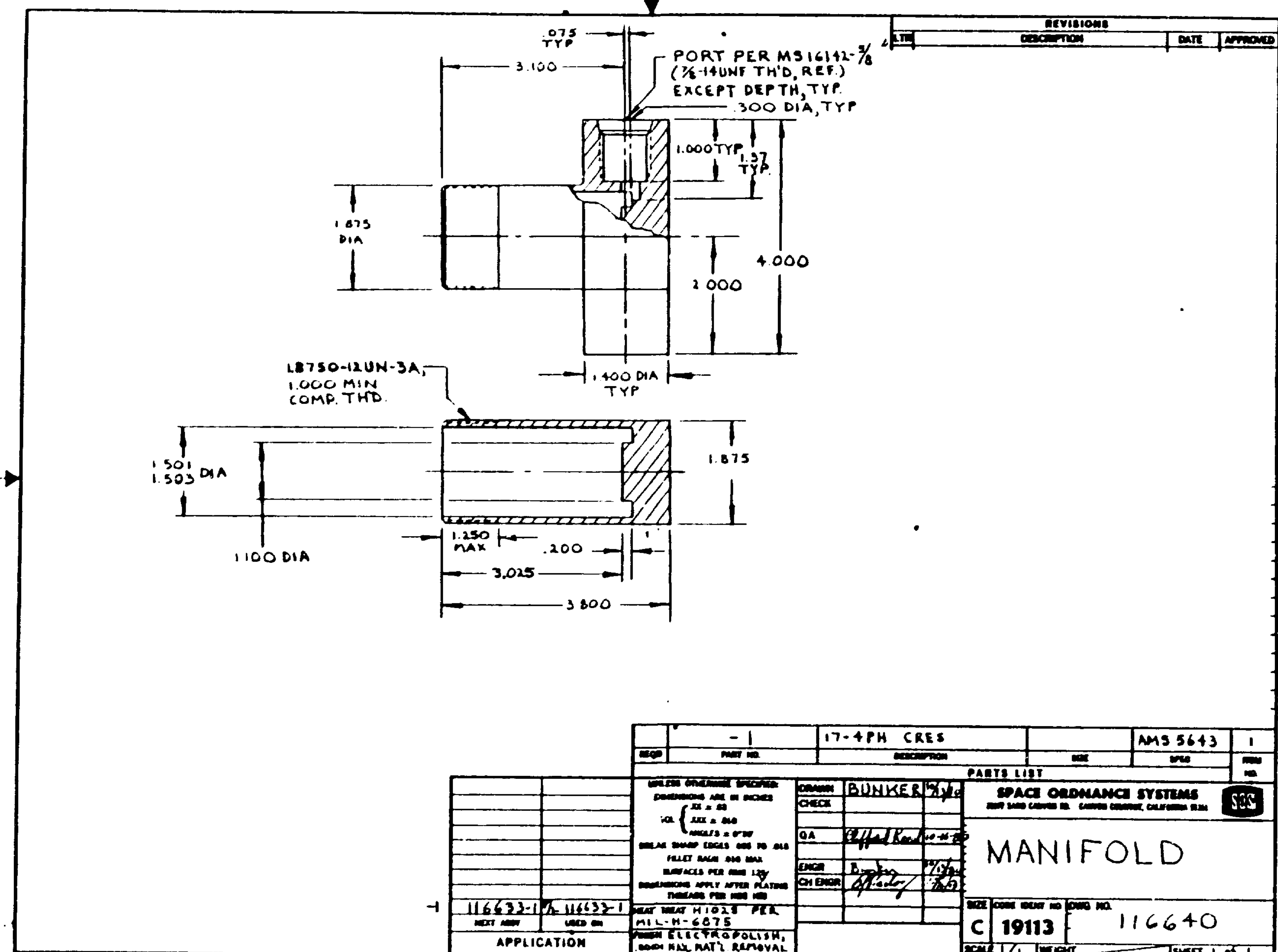
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1.000 TYP
1.37 TYP
1.875 DIA
4.000
2.000
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1.000 MIN
COMP. THD.
1.501
1.503 DIA
1.875
1.100 DIA
1.250 MAX
.200
3.025
3.800
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17-4PH CRES
AMS 5643
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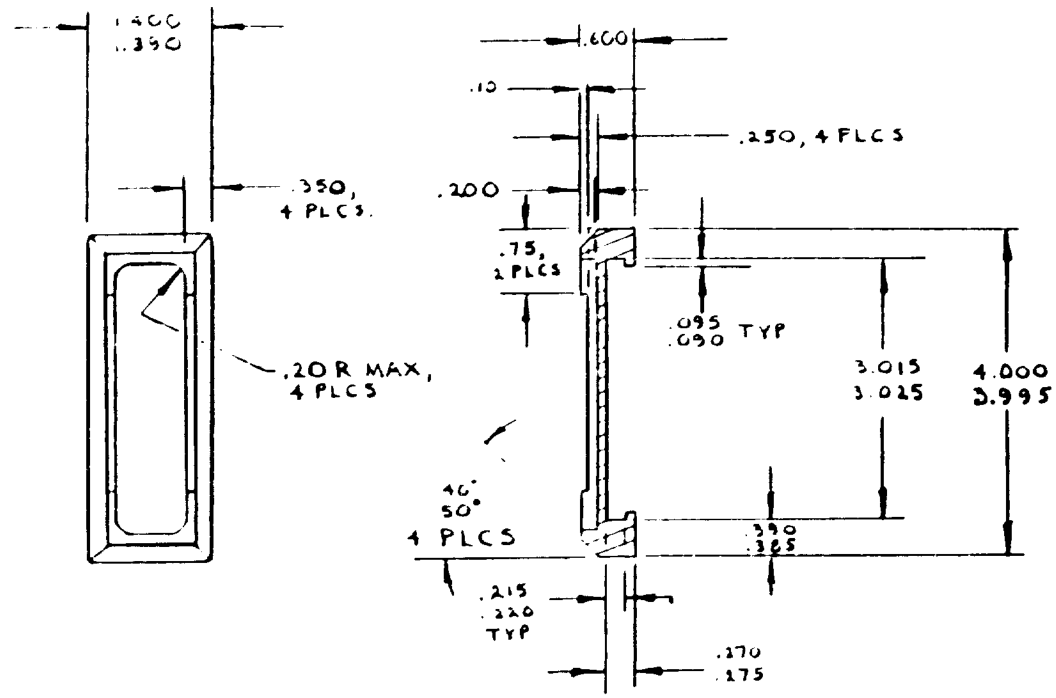
REQD
PART NO.
DESCRIPTION
SIZE
SPEC
ITEM NO.
PARTS LIST
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
DRAWN
BUNKER
CHECK
QA
ENGR
CH ENGR
SPACE ORDNANCE SYSTEMS
MANIFOLD
SIZE
CODE IDENT NO
DWG NO.
C
19113
116640
SCALE 1/1
WEIGHT
SHEET
116633-1
116633-1
NEXT ASSY
USED ON
APPLICATION
HEAT TREAT H1025 PER
MIL-H-6875
FINISH ELECTROPOLISH,
.0005 MAX MAT'L REMOVAL
116640

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



REQD	PART NO.	DESCRIPTION	SIZE	SPEC	ITEM NO.
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PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOL { .XX ± .03, .XXX ± .010, ANGLES ± 0°30'
BREAK SHARP EDGES .005 TO .015
FILLET RADII .010 MAX
SURFACES PER MIL 125
DIMENSIONS APPLY AFTER PLATING
THREADS PER NBS H28

HEAT TREAT

FINISH ALODINE PER MIL-C-5541

DRAWN	BUNKER 10/15/[illegible]
CHECK	
QA	Clifford [illegible]
ENGR	[illegible]
CH ENGR	[illegible]

NEXT ASSY	USED ON
116633-1	/L 116633-1

APPLICATION

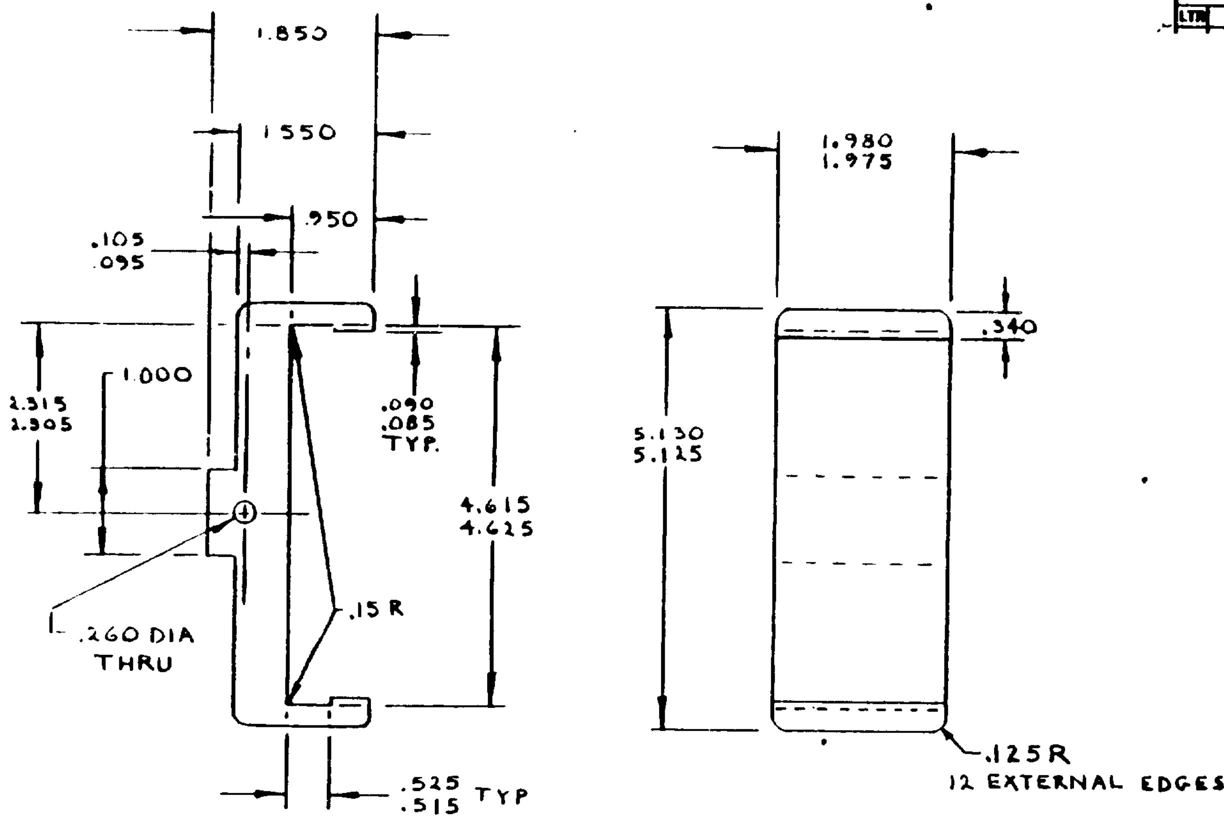
SPACE ORDNANCE SYSTEMS
25977 SAND CANYON RD. CANYON COUNTRY, CALIFORNIA 91351

ATTENUATOR

SIZE	CODE IDENT NO	DWG NO.
C	19113	116641

SCALE 1/1 WEIGHT SHEET 1 of 1

116641



2. FLUORESCENT PENETRANT INSPECT PER MIL-I-6866, TYPE I, METHOD B.

[1] HEAT TREAT TO 180KPSI MIN UTS PER PARA 3.4.1.2 OF AMS 5662.

REQD	PART NO.	DESCRIPTION	SIZE	SPEC	ITEM NO.
	-1	INCONEL 718		AMS 5662	1

PARTS LIST

NEXT ASSY	USED ON
116633-1	116633-1

APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOL .XX ± .03, .XXX ± .010, ANGLES ± 0°30'
BREAK SHARP EDGES .005 TO .015
FILLET RADII .010 MAX
SURFACES PER ANS 125
DIMENSIONS APPLY AFTER PLATING
THREADS PER NBS H28
HEAT TREAT [1]
FINISH

DRAWN	BUNKER	9/15/80
CHECK		
QA	Clifford Reed	10-6-80
ENGR		9/15/80
CH ENGR		

SPACE ORDNANCE SYSTEMS
25977 SAND CANYON RD. CANYON COUNTRY, CALIFORNIA 91351

END PLATE

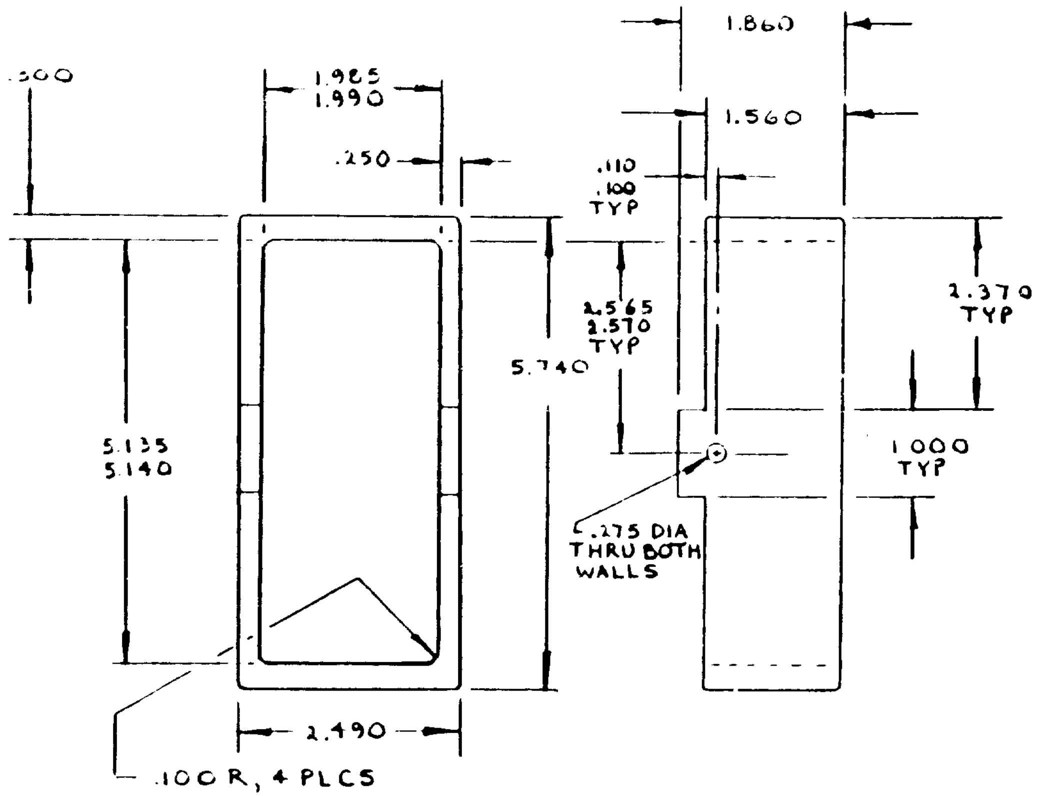
SIZE C | CODE IDENT NO. 19113 | DWG NO. 116642

SCALE 1/1 | WEIGHT | SHEET 1 of 1

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

116642



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REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

REQD	PART NO.	DESCRIPTION	SIZE	SPEC	ITEM NO.
	-1	17-4PH CRES		AMS 5643	1

PARTS LIST

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOL { XX ± .03 ; XXX ± .010 ; ANGLES ± 0°30'
BREAK SHARP EDGES .005 TO .015
FILLET RADII .010 MAX
SURFACES PER RMS 125
DIMENSIONS APPLY AFTER PLATING
THREADS PER MIL-H28

HEAT TREAT H1025 PER MIL-H-6875
FINISH ELECTROPOLISH, .0001 MAX MAT'L REMOVAL

DRAWN	BUNKER	10/1/80
CHECK		
QA	Clifford Reed	10-16-80
ENGR	Bunker	10/15/80
CH ENGR	[illegible]	10/16/80

NEXT ASSY	USED ON
116633-1	116633-1

APPLICATION

SPACE ORDNANCE SYSTEMS
25977 SAND CANYON RD. CANYON COUNTRY CALIFORNIA 91351

SOS

END COVER

SIZE C — CODE IDENT NO. 19113 — DWG NO. 116643

SCALE 1/1 — WEIGHT — SHEET 1 of 1

1024

116643

LTR	DESCRIPTION	DATE	APPROVED
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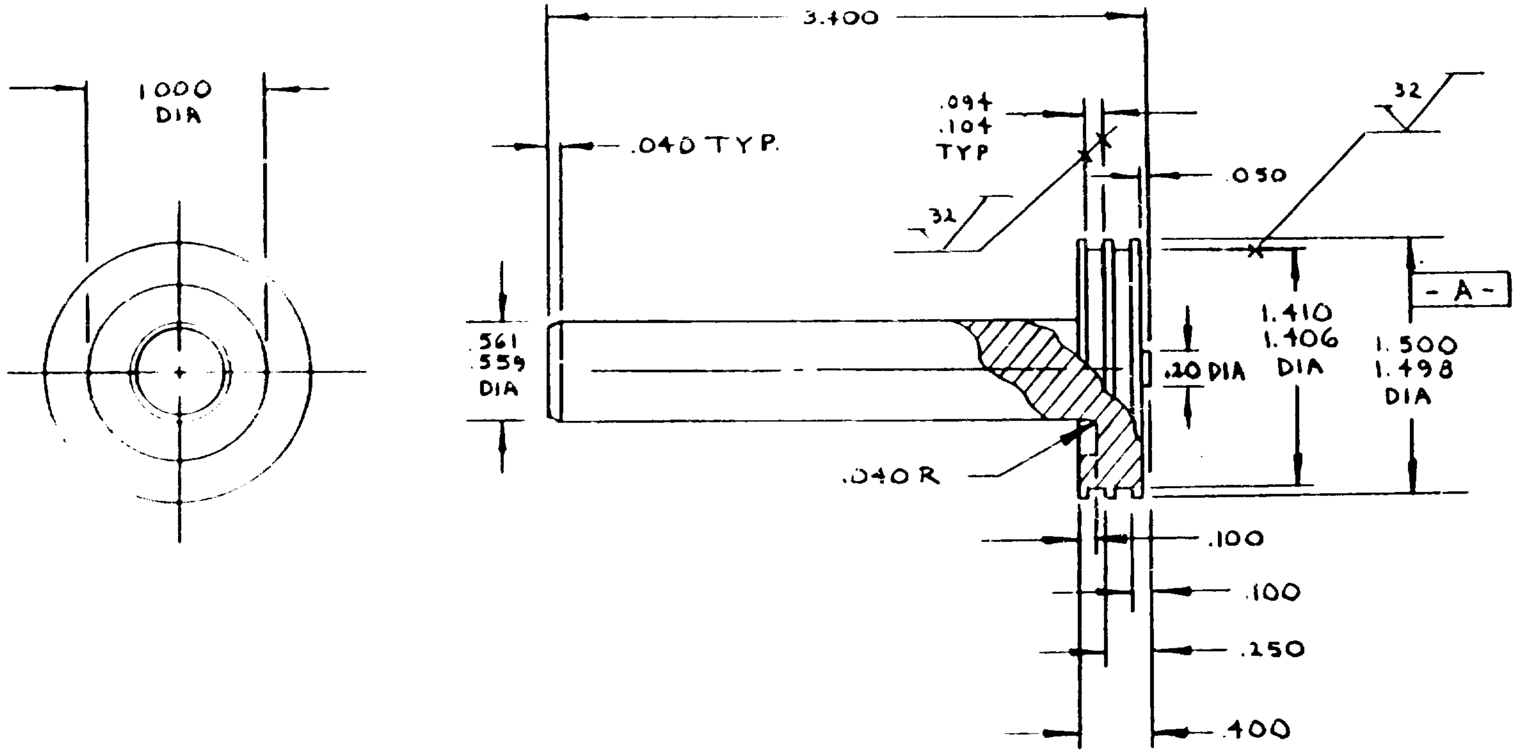


2. FLUORESCENT PENETRANT INSPECT PER MIL-I-6866, TYPE I, METHOD B.

[1] HEAT TREAT TO 180KPSI MIN UTS PER PARA 3.1.2 OF AMS 5662

REQD	PART NO.	DESCRIPTION	SIZE	SPEC	ITEM NO.
	-1	INCONEL 718		AMS 5662	1

PARTS LIST

NEXT ASSY	USED ON
116633-1	A 116633-1

APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOL: .XX ± .03; .XXX ± .010; ANGLES ± 0°30'
BREAK SHARP EDGES .005 TO .015
FILLET RADII .010 MAX
SURFACES PER MIL STD 125
DIMENSIONS APPLY AFTER PLATING
THREADS PER MIL STD [illegible]

HEAT TREAT [1]

FINISH ——

DRAWN	BUNKER	10/3/80
CHECK		
QA	Clifford Reed	10-16-80
ENGR	B[illegible]	10/13/80
CH ENGR	[illegible]	[illegible]

SPACE ORDNANCE SYSTEMS
20571 SAND CANYON RD. CANYON COUNTRY, CALIFORNIA 91351

PISTON

SIZE	CODE IDENT NO.	DWG NO.
C	19113	116644

SCALE 2/1 | WEIGHT | SHEET 1 of 1

A | 116644

IV. STRESS ANALYSIS

The device has demonstrated its ability to hold and release 80,000 pounds without damage to any of its main components. It even held 60,000 pounds when the shank was installed backwards. Ultimate destruction of the unit will therefore probably support the following calculations.

- Load Carrying Capacity.

As the shank is the central load bearing member, its diameter sets a limit on the load carrying capacity of the assembly. The present monoball accepts a 2.120 diameter, or an area of 3.530 square inches. For the shank, this area must do two things upon pre-loading: first, looking at the 2^{o} angle slider mating surfaces, the two lugs must support the preload in bearing and they must not shear off, and, second, the remaining cross-section must also support the preload in tension. As the shear strength is defined in the axial direction it is not involved in the cross-sectional area. Therefore, the bearing and tensile loads, being equal, should each receive half the area, or 1.756 inches. Then

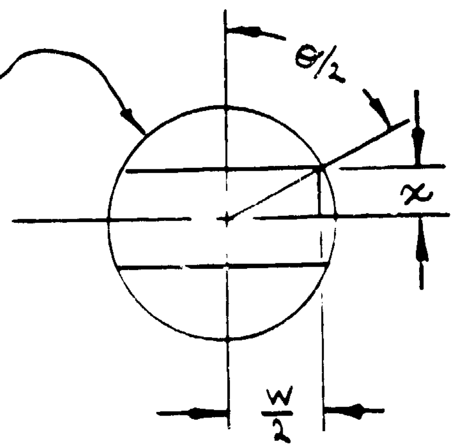
using 180,000 psi Min UTS Inconel 718, the shank will carry (1.756) (180,000)= 317,700 pounds. Allowing for tolerances, the figure may drop to 300,000 pounds.

Note that the 1.5 inch threaded end will provide less than 1.756 square inches. Computed at the P.D.:

$$(\pi/4)\ (1.394)^2=1.526 \text{ sq. ins.}$$

Calculation of the web thickness proceeds as follows:

Shank cross-section with radius R=1.060



$\text{Cos } (\theta/2)=X/R=X/1.060$

Each of the two segments has an area of 1.756/2=.878 ins. sq.

or

$.878=(R^2/2)(\pi\theta/180-\text{Sin}\theta)$

which by iteration yields, $\theta=132.05^\circ$

and $X=.4282$

or the web should be .856 thick.

Allowing for clearance, concentricity and radii, the web used is .850/.842 inches thick.

Calculation of the shear thickness is straight-forward. The lugs ride solidly and flatly on the mating slider surfaces and the slider rides solidly and flatly on the body and sleeve. There is therefore very little cantilevering, if any. In other words, the lugs will not tear off, they must shear.

The shear area is: (2) (.850)(W)=3.293 ins.

where W/2=RSin (132.05/2)=.9685

W=1.9371 inches

Assuming shear strength at 60% tensile:

the lugs will carry (.6)(180,000)(3.107)=

356,000 pounds, which is comparable to the cross-sectional strength.

o <u>Output Shock</u>.

From the design of numerous low shock devices it has become evident that the more a mounted device damages itself, the greater it shocks its surroundings. This device has come through the entire program almost unharmed. The theory used in designing the device ran as follows:

Actuate at 90° to the applied load.

Use smooth dry lubricated friction surfaces.

Release along a slight angle which proportionally relieves the load as the actuation pressure drops, thereby assuring

1. complete release using a small cartridge;

2. low terminal velocity of slider, and hence, low shock.

Attenuate slider impact.

The first two characteristics are clear and simple. The last, attenuation, worked satisfactorily, but, as described elsewhere, deserves redesign.

The third item, calculation of a release angle, is extremely difficult and the 2^{o} angle selected anticipated higher pre-loading than the 74,000 pounds presently required. Examination of the mating surfaces of the slider and the shank shows that the applied pre-load (80,000) is completely relieved before release. With no pre-load, the slider is essentially in free flight and accelerates to high velocity. It is recommended therefore that the release angle be reduced to 1.5^{o}.

The calculation depends on the elasticity of the column from the nut holding the yoke against the monoball to the lugs on the shank. An empirical deduction as described in the preceding paragraph cannot help but prove superior to numerical computation.

o <u>Assembly Weight</u>.

The complete assembly weighs 49 pounds. This can be reduced considerably by manufacturing the low stressed items of aluminum. The recommended components are the piston, manifold, follower, end cap, end cover and the largest portion of the body. These items weigh 20 pounds and are steel. Their weight will therefore reduce to approximately:

$$(20)\ (.098)/(.281)=7 \text{ pounds}$$

And the design will weigh

$$49-(20-7)=36 \text{ pounds.}$$

By reducing the stroke along with other design improvements, it is anticipated that another four (4) pounds will be removed producing an ultimate weight of approximately 32 pounds.

o <u>Actuation Pressure</u>.

The pressure required to actuate the unit using bottled gas and 80,000 pounds preload is 4000 psi. As this is a constant pressure rather than a momentary pyrotechnic type of peak pressure, it is a minimum, rather than a practical figure. Assuming a peak pressure of 5000 psi will start the slider moving and thus the coefficient of friction will change from standing to sliding, obviously the device will function completely.

Therefore, two 120% cartridges will produce

2(1.2)(5000)=12000 psi <u>locked shut</u>.

This is quite low compared with the measured 60,000 psi in the shear bolt and is comparable to the pressure regularly experienced in pin pullers and separation nuts, related mechanisms which also release at 90° to their applied loads and which normally have aluminum manifolds.

o <u>Hoop Stress in Manifold</u>.

Assuming Manifold is 7075-T73 Aluminum

Pressure is 12000 psi initially

The stress at the cartridge end of the manifold is:

$$S = PD/(D-d) = (12000)(1.875)/(1.875-1.503)$$

$$= 60{,}500 \text{ which equals the UTS}$$

It should be thickened at this end slightly. Note, however, that this end is not round and is supported on one end. Thus, a better informed analysis would reduce the computed stress considerably. Nevertheless, local expansion of only a few thousandths of an inch could cause o-ring failure with disastrous results. An increase in wall thickness is recommended.

o No other high stress conditions are known.

V. TEST PLAN

The general idea was to get as much information as possible from the one unit that had been manufactured. Eleven attenuators, five loadable cartridges, two inert plugs and one each of all other components were available. The results are described in the next section.

A. Load Sizing - Load sizing began in the gentlest possible method; by underloading to the point of failure. This was done while the unit was simultaneously being actuated with bottled nitrogen gas. Thus it became known approximately what load was required prior to any pyrotechnic actuations. SOS 109 powder was used because of its familiarity. We know what it does.

B. Functional Tests - Functional testing was also conducted for least and latest damage to the unit. First the unit was measured, then a light load applied and the unit re-measured. The load was increased and the unit measured again. This continued until the required actuation loads were

reached. Destructive testing has not been done.

Actuation started with (non-corrosive) bottled gas and a low tensile load with no shear load and no eject spring.

Firings began with intentionally underloaded single cartridge initiations and nominal tensile loading. This was increased cautiously and piece-meal to include a dual overload firing, shear loading and spring loaded shank ejection.

Figure VI -2 illustrates the test plan and results obtained.

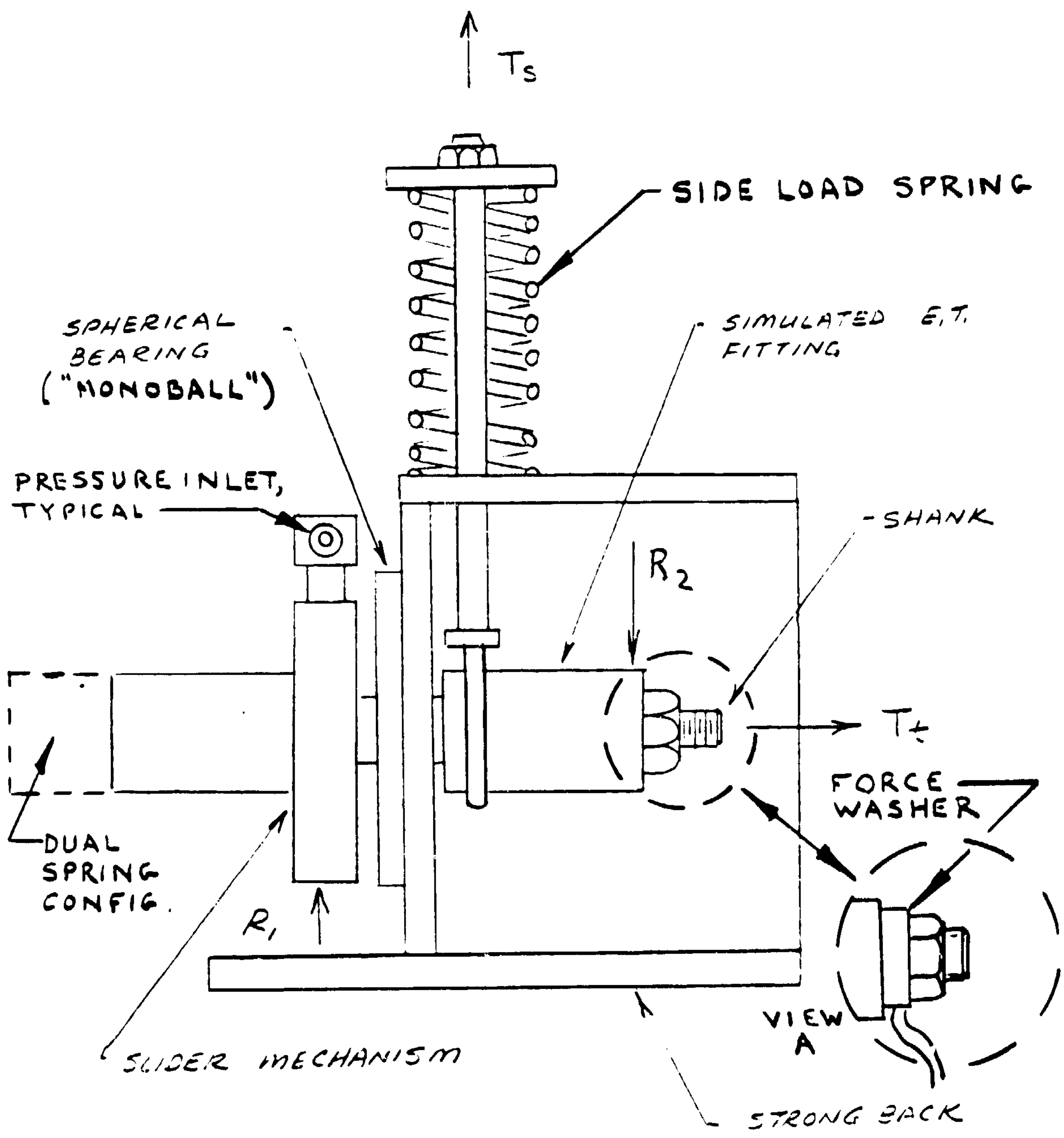
VI. TEST RESULTS

A. Test Set-Up - All actuation tests were performed in the set-up depicted in Figure VI-1. Not all actuations involved the ejection spring and not all involved side loads. The following text describes the pertinent details and the Test Log (Figure VI-2) completes the picture.

The force washer was first calibrated on a tensile test machine and then incorporated in the test set-up to determine the torque-tension relationship (see View A of Figure VI-1). Once established, the force washer was removed and the actuations begun.

The side load spring was also calibrated on the tensile test machine. It's final length at 1380 and at 1725 pounds were noted. (The spring is non-linear.)

The first tests involving side loads supported the mechanism against rotation in the monoball at R_1. Actuation



PROTOTYPE TEST SET-UP

Figure VI-1

in this cantilever condition was not achieved even though a new cover containing two ejection springs (series) was installed.

The final tests restrained rotation at R_2, thereby applying a fairly precise shear load to the shank at the monoball. In this configuration however, the side load had to be increased to 1725 pounds to achieve the 1380 required at the monoball. This set-up is not perfect - the simulated E.T. fitting could move axially away from the monoball for example - but the fact that the shank was ejected forcefully shows the importance of applying a true shear load as required.

TEST LOG, SLIDE RELEASE MECHANISM

#	ITEM	TEST SET-UP	POWER SOURCE	OBJECTIVE	RESULTS	COMMENTS
1	FORCE WASHER	TENSILE TEST MACHINE	HYDRAULIC	CALIBRATION	2785 μ" ~ 60K# 3285 ~ 70K 3785 ~ 80K	O.K.
2	SLIDE REL. MECH.	VIEW A OF FIGURE VI-1 NO SPRING, NO SIDE LOAD	MUSCULAR THRU 64:1 TORQUE MULTIPLIER	DETERMINE TORQUE/TENSION RELATIONSHIP	25 ft# ~ 60K# 50 ~ 80K	O.K.
3	" "	NO SPRING, NO SIDE LOAD 60K# TENSILE	BOTTLED N_2	WATCH FOR ABNORMAL LOAD	ACTUATED ON 3000 PSI	O.K. NO DAMAGE TO COMPONENTS
4	" "	NO SPRING, NO SIDE LOAD 80K# TENSILE	" "	SAME AS 3	ACTUATED ON 4000 PSI	EXCELLENT: LINEAR
5	" "	SAME AS 4	ONE CARTRIDGE, 400 mg, 505109	ACTUATION (NOT EXPECTED)	DID NOT RELEASE	INCREASE LOAD
6	" "	" "	ONE CARTRIDGE, 500 mg, 505109	ACTUATION	DID NOT RELEASE	" "
7	" "	" "	ONE CARTRIDGE 700 mg 505109	" (MORE THAN REQ'D)	RELEASED, NO DAMAGE	ASSUME THIS IS NOMINAL LOAD
8	" "	" "	DUAL 875 mg	WATCH FOR DAMAGE (OVERLOAD FIRING)	END PLATE BENT SLIGHTLY	TEN FIRINGS ASSURED.
9	" "	80K# TENSILE, 0 SIDE EJECT SPRING	DUAL 700 mg	VERIFY EJECTION	KNOCKED A BARREL OVER	O.K.
10	SIDE LOAD SPRING	TENSILE TEST MACHINE	HYDRAULIC	CALIBRATION	7" ~ 1380#	O.K.
11	SLIDE REL. MECH	80K# TENSILE, 1380 SIDE EJECT SPRING, R_1 SUPPORT CONFIG.	DUAL 700 mg	VERIFY EJECTION	EJECTION STOPPED 3" SHORT	FOLLOWER HUNG UP ON SLEEVE
12	" "	SAME AS 11 EXCEPT FOLLOWER MODIFIED	" "	" "	STOPPED 2½" SHORT	EJECT SPRING AND/OR SET-UP FAULT
13	" "	SAME AS 12 EXCEPT TWO SPRINGS IN SERIES	" "	" "	STOPPED 2" SHORT	CANTILEVER LOAD IS UNFAIR
14	SIDE LOAD SPRING	TENSILE TEST MACH.	HYDRAULIC	CALIBRATION	6" ~ 1725#	O.K.
15	SLIDE REL. MECH.	SAME AS 13 EXCEPT R_2 SUPPORT CONFIG. & 1725# SIDE LOAD	DUAL 700 mg	VERIFY EJECTION	SHANK & FIRING FIXTURE HIT WALL	EXCELLENT
16	" "	SAME AS 15	" "	" "	SAME AS 15	"
17	" "	80K TENSILE, 1725 SIDE ORIGINAL DESIGN, ONE SPRING, R_2 SUPPORT	" "	" "	COMPLETE RELEASE, HOLE CLOSED AGAINST 25 POUND	ORIGINAL DESIGN CONCEPT PROVEN. EJECT SPRING NEEDS IMPROVE
18	" "	SAME AS 17	" "	"	SAME AS 17	CONFIRMATION

NOTES: ALL TEST SET-UPS PER FIGURE VI-1 EXCEPT AS NOTED
INITIATION BY NSI-1 IN ALL FIRINGS

FIGURE VI-2

B. Test Results - Numerous minor difficulties were encountered, mostly with the test apparatus, a few with the design, but it is deemed by SOS that the program was quite successful.

The four most expensive components in the device, the body, shank, sleeve and slider, but for some foolish man-handling, would be virtually unchanged now at the end of the program from their initial received condition.

The die spring and follower are as good as new. With the use of a gear puller for disassembly the end cover will survive undamaged and with the addition of a wrenching hex, the cover will also survive undamaged.

Re-usability is proved.

Only 0.7 grams of powder are required for actuation (versus 12.0 and 13.2 grams in the separation and shear bolt), thus shock reduction during release is guaranteed.

Shank ejection was achieved forcefully after modification of the test set-up following three failures.

Analysis showed that cantilever loading rather than the required shear loading had been applied. Closure of the monoball by the follower is very precise. Some re-design is advisable in this area, possibly involving a specially designed die spring, and certainly involving dimensional improvements. A stock die spring was used. SOS, nevertheless, feels that reliable, precise ejection is proven feasible.

Ultimate strength of the unit has not been tested; it would destroy the unit. The unit is clearly capable of carrying the required loads. It was assembled incorrectly once and tensed to 60,000 pounds. The force washer used in the set-up indicated that something was yielding very slowly. Disassembly showed that the shank had been mated with the slider in reverse: the 2° angled surfaces were out of phase, and the load had initially been applied to a point which naturally yielded. The 60,000 pounds was held by an area 1/4 inch square. A little grinding of the O.D. and the shank was used ten times thereafter. A slight dimension change will prevent this from happening.

VII. RECOMMENDATIONS

A. Slider Design - The recommendable improvements can best be described from a component standpoint.

Shank

The shank was installed in the device incorrectly. This possibility must be eliminated. It is apparently the only part with this fault. Most of the components are symmetric. The slider and body are not, but they cannot be mis-assembled. If the slider is installed in the body either upside down or backwards or both, either the sleeve or the shank will refuse to enter.

The 2° angle mating with the slider should be reduced to 1.5°. The 2° angle was selected in expectation of larger tensile loading. A shallower angle will provide lower shock for two reasons:

- A smaller shear pin can be used; and
- The pre-load will slow down the slider during a longer portion of its release stroke.

Elimination of the release angle is not recommended. Cartridge loading would increase significantly and brinelling of the shank and slider would not only be real but could affect ejection of the shank.

Attenuator

The attenuator was poorly designed. It functioned satisfactorily, but could be much improved. It did attenuate and it did capture the slider at stroke completion.

Cover

The cover needs a wrenching hex, a viewing port to detect engagement of the follower lugs with the keys in the sleeve, lockwire holes and threaded closures of the viewing port and end port for environmental protection.

Follower

The follower can be made of aluminum, can be shortened along with a general redimensioning of the ejection stroke components. From hindsight it is evident that the follower stroke can be reduced.

Spring

The shank ejection spring must be re-designed. It's stroke length is inadequate. After ejection it does not forcefully keep the follower in position. (75 pounds is required.)

Sleeve

The sleeve needs to be internally "chamfered" to assure that neither the shank nor the follower can hang up on a sharp edge during ejection. (This did happen.)

Manifold

The manifold can be made of aluminum and can have its cartridge ports at any convenient angle.

Piston

The piston also can be made of aluminum. Forces and pressures are low.

Body

The body should be made of two pieces, with only a flat plate being made of inconel and the great majority aluminum.

B. <u>Test Fixture</u> - The functional test fixture consisted of a flight type spherical bearing mounted in a strong back base. The tension load was applied by pre-tensioning the shank by torquing thru a simulated External Tank Fitting. The shear or side load was applied with a spring load applied to the E.T. fitting by a harness.

The initial side load testing was set up with T_t, T_s and R_1. This resulted in a couple at the shank bearing interface which did not simulate a side load T_s. Subsequent tests were set up with T_t, T_s and R_2. This resulted in full separation of the shank from the spherical bearing.

It is recommended that subsequent tests be conducted in a fixture which simulates the shear load. Several options are available for this:

1. Fabricate a new fixture.
2. Modify existing obsolete fixtures.
3. Utilize existing fixtures.

As the spherical, E.T. fitting, shank interface is identical to the existing separation bolt, installation will not be a problem.

C. Follow-On Program - This section is prepared to identify what items are required to complete a formal design, development and qualification program consistent with the JSC 8060 requirements.

The design tasks to be accomplished include:

1. Envelope Analysis - As the geometry of the slide is considerably different, a review of the surrounding Orbiter structure would be required to verify envelope compliance.

2. Centering Mechanism Design - A secondary function of the mechanism is to accommodate an 11° deflection in the spherical bearing prior to separation and return to the upright position after separation. The design of a centering mechanism, of similar design to the existing design, will be required.

3. Gas Actuated Shank Follower - It may be desirable to incorporate a gas driver shank follower utilizing the same pressure sources (cartridges) which drive the slider. This would achieve higher initial forces than would be available with a spring.

4. Shear Pin - A shear pin design, sized for optimum slider retention. In addition, some means of shear pin integrity verification will be incorporated.

5. Weight Reduction - The design shall incorporate all features to minimize weight. Material selection will also

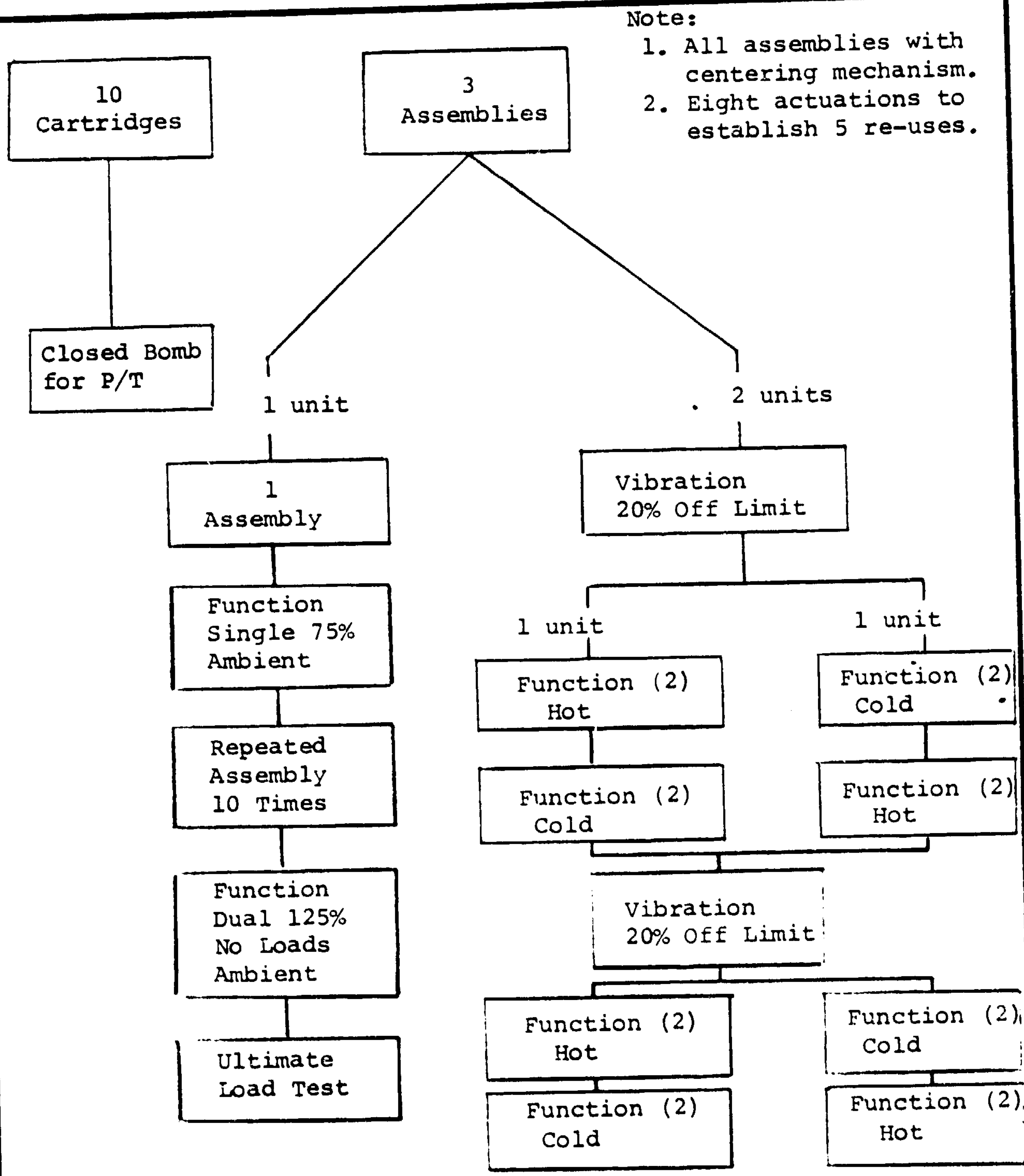
be reviewed with regard to weight reduction.

6. Test Fixture - The design and fabrication of the test fixture will be carefully coordinated with NASA to ensure simulation of the actual vehicle loads. All effort will be made to utilize existing fixtures or modifications to existing fixtures.

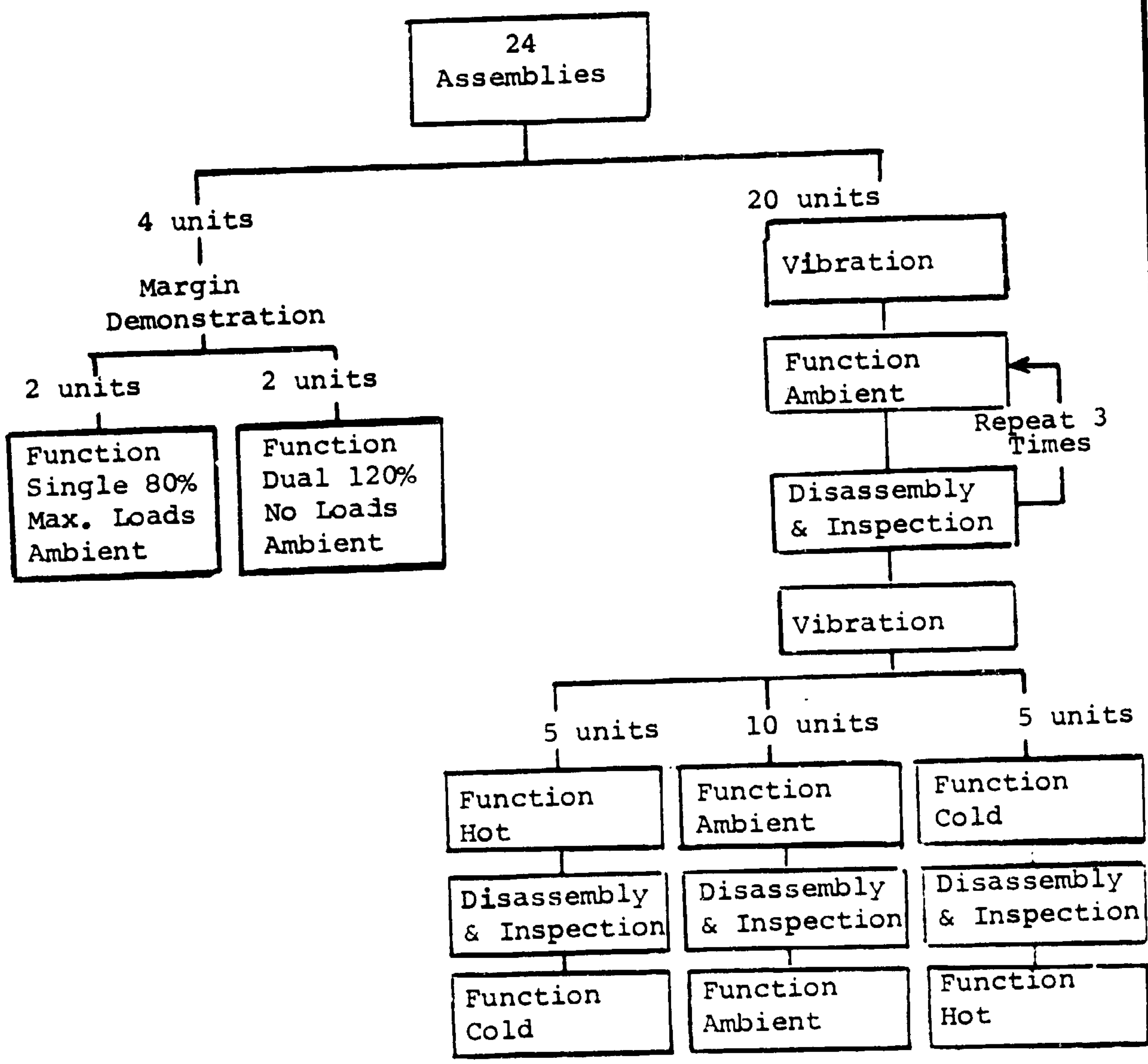
Development testing would be conducted on three (3) units of the final design. Additionally, ten (10) cartridges with the final load would be tested in a closed bomb to establish acceptance criteria for subsequent production lots. Margins in environmental exposure and cartridge loads would be verified. Figure VII-1 illustrates the development test plan.

The qualification would consist of twenty-four (24) specimens. The qualification and deliverable units would be manufactured at the same time for cost savings. The qualification test would simulate flight conditions and re-use of the components. Figure VII-2 illustrates the tests and sequence of the qualification.

At the conclusion of the qualification, the deliverable units would be released for flight installation. The schedule



Development Test Plan
Figure VII-1



Qualification Test Program
Figure VII-2

to complete a full scale development and qualification program would be 12 - 14 months.

VIII. CONCLUSIONS

This program has demonstrated a conceptional release mechanism can be fabricated which will be interchangeable with the existing Orbiter/External Tank Separation Bolt which offers the following advantages.

- o Reduced weight.
- o Reduced shock.
- o Reuseable components.
- o Reduced cost.

The prototype demonstration withstood multiple actuations and load applications and remains in useable condition for further demonstration.

The application of simulated loads is a critical item as the variation in predicted loads by analysis is not accurate.

A follow-on program has been identified which would incorporate all design recommendations and verify flight conditions in a qualification series. It is expected flight

release mechanisms would be available 12 - 14 months after go-ahead.

APPENDIX A

NASA STATEMENT OF WORK

Enclosure 2

EXHIBIT A

STATEMENT OF WORK

Program entitled "Prototype Demonstration of a Slider Release Device for Orbiter/External Tank Forward Attach"

Technical Requirements

The contractor shall accomplish the following tasks:

A. Develop a preliminary design of a low shock Orbiter/External Tank separation device with centering provision and aperture closeout utilizing a keyed slider and bolt arrangement in accordance with the attached or similar concept sketch. Interface loads and envelope are as specified in Rockwell MC 325-0014.

B. Perform a stress analysis of the preliminary design.

C. Prepare prototype detail and assembly drawings in preparation for manufacture.

D. Conduct a Preliminary Design Review with NASA prior to hardware fabrication.

E. Fabricate prototype hardware with planned refurbishment of 10 times.

F. Conduct ten functional tests including:

   1. Cartridge load sizing.

   2. Margin tests.

   3. Ultimate combined load test.

REPORTING REQUIREMENTS

The contractor shall provide brief and informal monthly reports which contain a description of progress achieved during the reporting period, problems and planned corrective action, and plans for the next reporting period. Five copies of the monthly report shall be provided to the NASA technical monitor.

The contractor shall prepare a contract final report which shall document in detail all the work performed during the program, including data, analyses, and interpretations, as well as recommendations and conclusions based on the results obtained. The report shall include tables, diagrams, curves, drawings, and photos as required, in sufficient detail to comprehensively explain the results obtained. Ten copies of the final report shall be submitted to the NASA technical monitor.

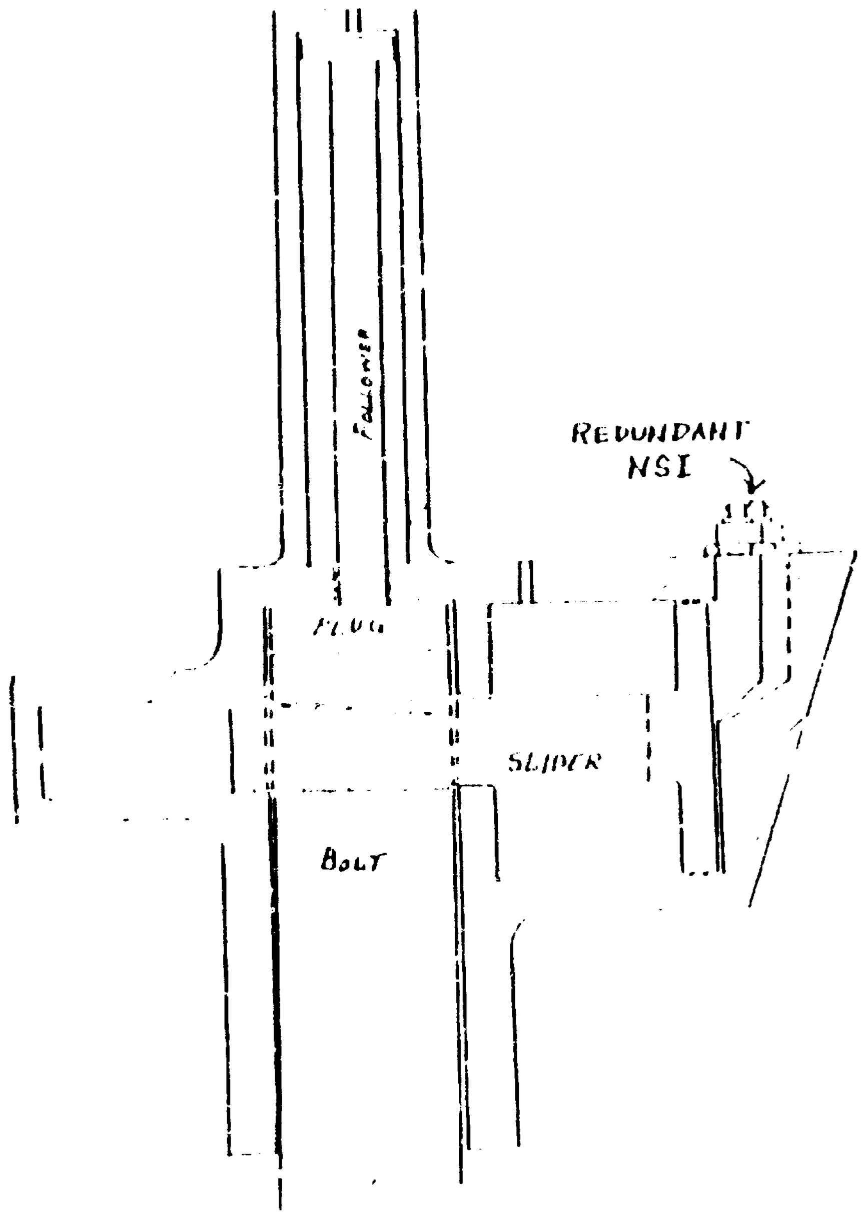
SCHEDULE REQUIREMENTS

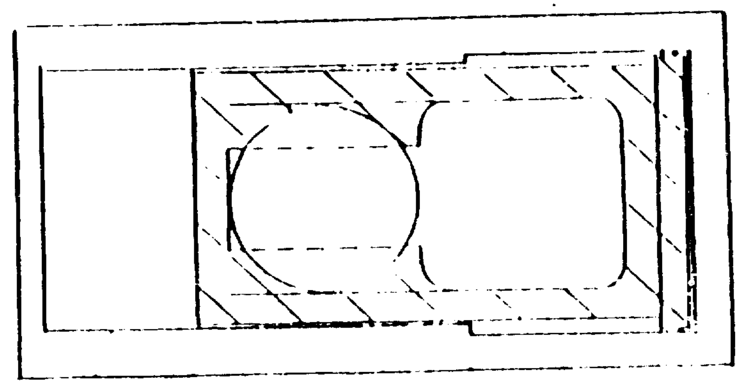
The technical requirements of this Statement of Work shall be complete six months after contract initiation. The final report shall be submitted seven months after contract initiation.

NASA Lyndon B. Johnson Space Center

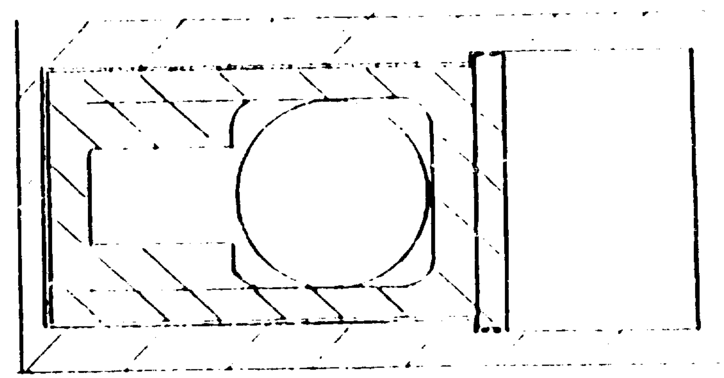
Engineering and Development Directorate

SLIDER CONCEPT



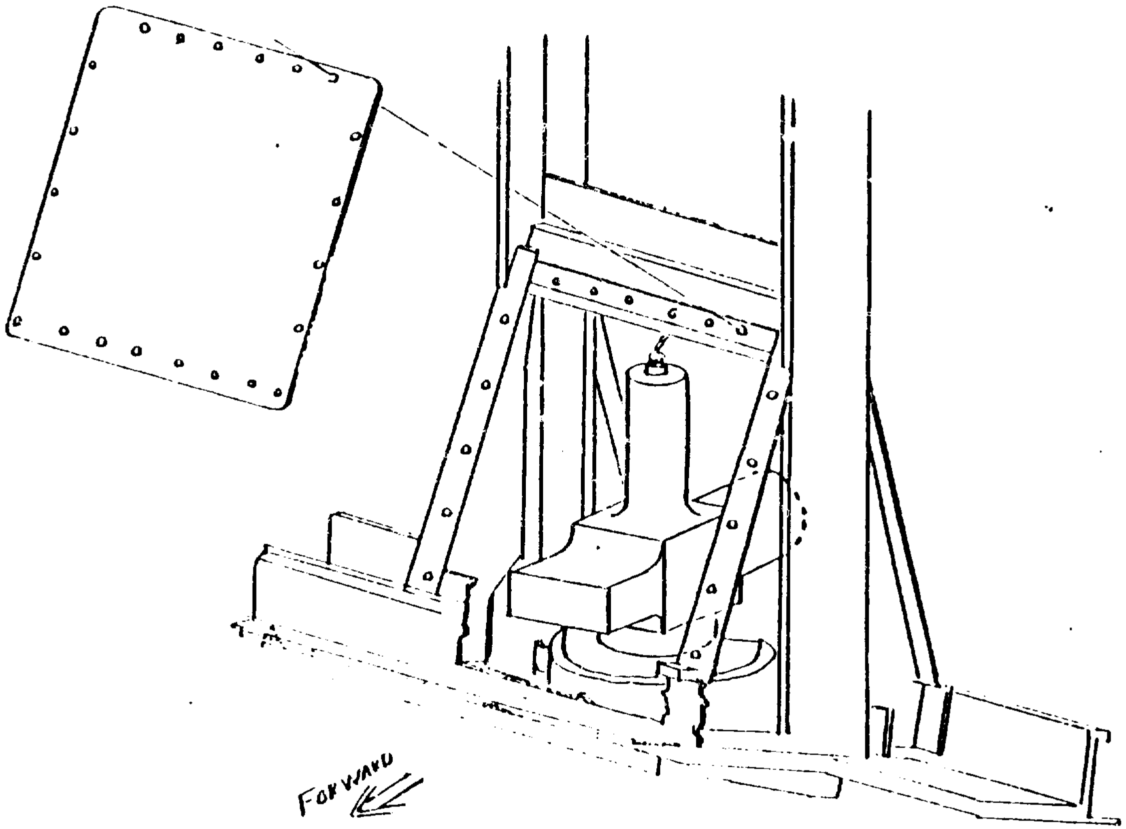


BEFORE ACTUATION



AFTER

SLIDER CONCEPT INSTALLATION



APPENDIX B

NEW TECHNOLOGY DISCLOSURE

A DIVISION OF

TransTechnology CORPORATION

SOS

In Reply Refer to
PMO 11457
26 January, 1981

NASA
Johnson Space Center
Houston, Texas 77058

Attention: Mr. John T. Wheeler, Technology Utilization Officer

Subject: Contract NAS 9-16169

Reference: (A) SOS File 3F-1024-I0-10
(B) NASA Form 666A
(C) Slide Release Mechanism 116633-1

Gentlemen:

In accordance with the New Technology Reporting requirements of the subject contract, enclosed is NASA DD Form 666A.

A complete technical disclosure will be available in April 1981. Should you have any further questions do not hesitate to contact the undersigned at A/C 805- 252-6220.

Very truly yours,

TRANSTECHNOLOGY CORPORATION

Robert S. Ritchie
Program Manager
Space Ordnance Systems

RSR/sc

ENCLOSURE

cc: Jim Bunker

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NEW TECHNOLOGY REPORT

NT CONTROL NO. *(Official use only)*

INSTRUCTIONS

This report form may be used when reporting inventions, discoveries, improvements or innovations to NASA. Use of this report form is optional; provided, however, that whatever report format is used contain the essential information requested herein.

Please provide information requested in each section as follows:

Section I - A description of the problem that motivated the technology development.

Section II - A technically complete and easily understandable description of the new technology that was developed to solve the problem or meet the objective.

Section III - The unique or novel features of the technology and the results (or benefits) of its application.

Section IV - The inclusion or listing of any pertinent additional documentation or references which aid in the understanding or application of the new technology.

In completing each section, use whatever detail deemed appropriate for a "full and complete disclosure," as required by the New Technology or Property Rights in Inventions Clause. For further guidance as to what constitutes a satisfactory report, please refer to NHB 2170.3, Documentation Guidelines for New Technology Reporting.

Available additional documentation which provides a full, detailed description should be attached, as well as any additional explanatory sheets where necessary.

1. TITLE

SLIDER RELEASE ASSEMBLY, SOS P/N 116633-1

2. INNOVATOR (S) *(Name and Social Security No.)*

James W. Bunker [redacted] Robert S. Ritchie [redacted]

3. EMPLOYER *(Organization and division)*	4. ADDRESS *(Place of performance)*
TransTechnology Corp. Space Ordnance Systems Div.	25977 Sand Canyon Rd. Canyon Country, Ca. 91351
5. NASA PRIME CONTRACT NO.	6. CONTRACTOR DISCLOSURE NO.
NAS 9-16169	NAS9-16169

SECTION I - DESCRIPTION OF THE PROBLEM THAT MOTIVATED THE TECHNOLOGY DEVELOPMENT *(Enter A.-General Description of Problem Objective; B.-Key or Unique Problem Characteristics; C.-Past History/Prior Techniques; D.-Limitations of Prior Techniques)*

Invent/design a mechanism which would replace the shearbolt, MC352-0012-0014 presently qualified for use

With the required objective of reducing the output shock caused by actuation of the device and with the desired objectives of

1. Permitting multiple use of a single unit and
2. Reducing unit weight.

NASA FORM 666A APR 69

SECTION II - TECHNICALLY COMPLETE AND EASILY UNDERSTANDABLE DESCRIPTION OF NEW TECHNOLOGY THAT WAS DEVELOPED TO SOLVE THE PROBLEM OR MEET THE OBJECTIVE *(Enter as appropriate A.-Specific description of item; B.-State of development; C.-Operation as a unit; D.-Functional operation; E.-Supportive theory; F.-Engineering specifications; G.-Peripheral equipment; H.-Drawings, graphs, etc.; I.-Parts or ingredients lists; and J.-Maintenance, reliability, safety factors)*

A.I To significantly reduce the shock, the force required to actuate the device must be reduced accordingly. This is impossible as long as it is required to break a section that is stronger than the load to be carried.

The mechanism, therefore must be "prebroken." With such a mechanism, actuation should be at approximately 90° to the carried load. This will assure minimum actuation force and maximum resistance to external forces such as shock, vibration and thermal cycling.

II Numerous devices satisfying AI above are already in existance, but, in general, they contain more moving parts than separation bolts or shearbolts. They are less desirable in certain types of reliability analysis.

The described device contains a minimum number of moving parts; no more than the present Shearbolt.

III With the lower actuation forces, the weight can be substantially reduced.

IV With the elimination of metal deformation during actuation, a unit can certainly be used several times.

SECTION II (Con.)

SECTION III - UNIQUE OR NOVEL FEATURES OF THE TECHNOLOGY AND THE RESULTS (OR BENEFITS) OF ITS APPLICATION (*Enter as appropriate A.-Novel or unique features; B.-Development or conceptual problems; C.-Operating characteristics, test data; D.-Analysis of capabilities; E.-Source of error; and F.-Advantages/shortcomings:*)

1) Actuation, and consequently the bulk of the unit, is at 90° to the load axis. The writer knows of no other release mechanism with this feature. (A pin puller does not of itself hold the parts together: it relies on assistance from the parts themselves) . This "sidewise" feature could be of value in small diameter missiles and other restricted spaces.

2) The device, with minor refurbishment, is re-usable.

3) As shown, it requires a push on the slider for actuation. This could be reversed- in other words, requires a pull. Pulling could prove to be the better method.

SECTION III (Con.)

SECTION IV - ADDITIONAL DOCUMENTATION *(Include or list below any pertinent documentation which aids in the understanding or application of the new technology. IF NOT TOO BULKY OR DIFFICULT TO REPRODUCE, INCLUDE COPIES WITH THIS REPORT. For those references or additional documentation available but NOT included in this report (due to their being nonessential to a basic understanding of the new technology and which may be costly to reproduce or handle) complete item A. below)*

A. AVAILABLE DOCUMENTS *(Check and complete)*		1. PAPERS, ARTICLES	X	4. ASSEMBLY/MFG. DRAWINGS	X	7. TEST DATA
		2. CONTRACTOR REPORTS	X	5. PARTS OR INGRED. LIST		8. ASSEMBLY/MFG. PROCED.
		3. ENGINEERING SPECS.		6. OPERATING MANUALS		9. COMPUTER TAPES/CARDS
	10. OTHER *(Specify)*					

B. INDICATE THE DATES OR THE APPROXIMATE TIME PERIOD DURING WHICH THIS TECHNOLOGY WAS DEVELOPED *(i.e., conceived, constructed, tested, etc.)*

September 1979

C. LIST THE FIRST PUBLICATION OR PUBLIC DISCLOSURE OF THE NEW TECHNOLOGY, AND DATES

Space Ordnance Systems Proposal 3F-PRO-00-1589-GO

D. LIST THE DATES AND ANY PARTICULARLY PERTINENT PAGE NUMBERS OF OTHER PUBLICATIONS WHICH ARE AVAILABLE BUT NOT ATTACHED

E. DEGREE OF TECHNOLOGICAL SIGNIFICANCE *(Check in your best judgment the statement which best expresses the degree of technological significance of this technology)*

[X] 1. MODIFICATION TO EXISTING TECHNOLOGY [ ] 2. SUBSTANTIAL ADVANCE IN THE ART [ ] 3. MAJOR BREAKTHROUGH

COMMENTS

Complete disclosure available April 1981

SIGNATURE OF INNOVATOR(S)	DATE
James W. Bunker Robert Bitche	1-12-81